INFLUENCING THE CALLING OF SEA ROBINS (PRIONOTUS SPP.) WITH SOUND [1, 2, 3]

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Despite abundant evidence that fishes hear and produce sounds (Fish, 1948, 1954; Griffin, 1955; von Frisch, 1938), a review of the literature (Moulton and Backus, 1955) on attempts to influence fish movements with man-made sounds has uncovered reports only of quickened movements of fishes during production of such sounds. Nor has a biological significance of any sound known to stem from a fish, whether produced by stridulation of skeletal parts or by the air bladder, been clearly demonstrated. However, the apparent relationship between sound-production by some species of fishes and their respective breeding seasons has been noted by a number of authors (Fish, 1954, pp. 51, 83; Goode, 1888, p. 137; Marshall, 1954, p. 254), and the possible significance of fish calls in bringing individuals of the same species together has been suggested. Sounds are also produced during defensive spine raising of such fishes as groupers, grunts, squirrel fishes and sea robins.

During the summer of 1954, it was accidentally discovered that the production of certain fish calls, later identified as the calls of sea robins, could be stimulated by transmission of certain sounds into the water, and that the calling could be suppressed by other sounds (Moulton, 1955). The study resulting from this finding was pursued further during the summer of 1955. The observations yielded evidence that calls produced during the breeding season of two species of sea robins (*Prionotus carolinus* L. and *P. evolans* L.) are produced as responses to calls of the same species, and that by the transmission of appropriate sounds, some degree of control over the calling of sea robins may be exercised.

The sound-generating equipment employed in the experiments here described consisted of a Hewlett-Packard audio oscillator Model LAJ or a Magnecorder tape recorder Model PT6J; either an Altec Type A-323B or a Craftsman Model C550 amplifier, and a QBG transducer. The monitoring system was an AX-120 ADP or an AX-58-C Rochelle salt hydrophone and a Woods Hole Suitcase amplifier. Recordings were made on the Magnecorder tape recorder at a speed of 15 in./sec. and were analyzed on a Vibralyzer vibration analyzer. The experiments were performed from a raft anchored over 72 feet of water in Great Harbor, Woods Hole, Massachusetts.

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The Sounds of Sea Robins

The sound-producing air bladder of the sea robin has been described by Fish (1954). It is the apparent source of two different calls. One of these calls is a vibrant grunt produced when a sea robin is handled in or out of water, and when a sea robin is brought to the surface by net or by hook and line. The grunt accompanies fin erection.

As determined by vibration analysis, the sea robin grunt is a single burst of noise lasting about $\frac{1}{10}$ second. The upper frequency limit is approximately 1.7 kc., the lower below 44 cps. The grunt is audible to the unaided ear above the water when a sea robin is submerged four feet beneath the surface. Noises of frequency characteristics similar to those of the grunt may be obtained by pressing the air bladder through the ventral body wall of the intact fish, and by stimulation of the nerves to the drumming muscles located on the lateral surfaces of the bilobed air bladder.

The onset of the breeding season of the sea robins at Woods Hole is marked by the production by these fishes of a staccato call. Although this call has been monitored from sea robins contained within a live car at the surface of Great Harbor, no single fish has been identified as the source of an individual call. This call is not produced under conditions that bring forth the grunt already described, and it is much more frequently produced by fishes in the Harbor than by caged specimens.

The breeding season of the sea robins at Woods Hole extends from June to September, with July and August the height of the season (Bigelow and Schroeder, 1953). In 1955, listening began on 29 June. The first staccato calls were heard on 5 July, and calls were heard on each day of listening thereafter until work terminated for the summer on 30 August. The number of outbursts of calling and the number of calls comprising a single outburst increased rapidly during the first half of July (compare Tables I and II). During the latter part of August calling became more infrequent.

Table I

Responses of sea robins to audio oscillator signals in Great Harbor, 15 July, 1955

Time	Number of signal transmissions	Response
1415	1	2 calls
1420	1	No calls
1430	1	No calls
1440	1	No calls
1450	1	No calls
1500	2	1 call after first signal
1510	3	1 call after first signal
1520	2	No calls
1530	2	No calls
1540	2	1 call after first signal
1550	3	1 call after second signal
1600	2	No calls
1610	4	1 call after signals one and two
1620	3	No calls
1630	3	No calls

TABLE II

Responses of sea robins to recordings of the staccato call and to audio oscillator signals, Great Harbor, 20 July, 1955

Time	Number and type of signal transmission	Response
1425	1 recording	2 calls
1430	1 signal	No calls
1435	1 recording	No calls
1440	1 signal	No calls
1445	1 recording	4 calls
1450	1 signal	No calls
1455	1 recording	No calls
1500	1 signal	2 calls
1505	1 recording	No calls
1510	1 signal	No calls
1515	1 recording	No calls
1520	1 signal	6 calls
1525	1 recording	No calls
1530	1 signal	No calls
1535	1 recording	No calls
1540	1 signal	No calls
1545	1 recording	No calls
	(5 spontaneous calls during this interval)	
1550	1 signal	No calls
1555	1 recording	No calls
1600	1 signal	No calls
1605	1 recording	No calls
	(12 spontaneous calls during this interval)	
1610	1 signal	No calls
1615	1 recording	No calls
1620	1 signal	No calls
1625	1 recording	No calls
1630	4 signals	1 call after No. 2
1635	3 recordings	No calls
1640	3 signals	No calls

The staccato calls consist of pulses of noise usually produced in pairs, at an average rate of 22 pulses/second. The paired arrangement of the pulses in a typical call is probably due to a slightly asynchronous contraction of the drumming muscles on the two lobes of the air bladder. The pairing of the pulses is not distinguishable to the ear, but can be seen on vibration analysis. Absence of the double pulses in a portion of some calls and, rarely, throughout a call suggests that one lobe of the air bladder may be silent during sound production by the other lobe.

The individual pulses of the staccato call lie between 500 cps and 4 kc. The frequencies of greatest intensity lie between 700 cps and 2.5 kc. The respective intensity peaks of the paired pulses are at different frequencies on the vibragrams, separated by approximately 1 kc. This is presumably related to a differential resonance of the two air bladder lobes which generally differ somewhat in size. It is possible to obtain sounds of similar frequency and intensity characteristics by palpitation of the dissected air bladder.

Influencing Production of the Staccato Call

With the sound-generating equipment employed, it is possible to transmit a series of sound pulses crudely imitative of the staccato call of the sea robin when the audio oscillator is set at 17 to 40 cps. (The QBG emits a considerably distorted wave train when driven with a sine wave at these frequencies.) With transmissions timed to correspond to the duration of an average call, 2½ to 3 seconds, production of the staccato call by free sea robins was repeatedly incited during July and August of 1954 and 1955.

Tables I and II present the results of two experiments extending over 2 hours and 15 minutes on 15 and 20 July, 1955. On 15 July (Table I) from one to three imitations of the staccato call were transmitted at ten-minute intervals, except for the second trial which followed the first by five minutes. Of the 15 trials, 6 were followed immediately by calling of free sea robins. There was no calling during the listening period other than immediately following signal transmissions.

On 20 July (Table II), playing of recordings of the sea robin staccato calling into the harbor water was alternated with transmission of imitations of the calling at five-minute intervals. During the 28 tests of 20 July, the calling of free sea robins was heard five times immediately following transmissions, twice after playing recordings of the calling and three times following transmissions of the imitations. Two spontaneous outbursts, frequent by 20 July, were heard during the period of the experiment. As Table II also indicates, outbursts of several calls were the rule by 20 July, whereas earlier in the month single or double calls comprised the characteristic outburst in 1955.

Suppressing of the Staccato Call

Signals of 200 to 600 cps transmitted for the approximate duration of a staccato call interrupt the production of this call by sea robins. (Again the QBG signal is considerably distorted as at the lower frequency.) Signals above 2 kc. have never been effective in suppressing the calling. Signals from 600 cps to 2 kc. are variable in effectiveness. Sea robins confined in a live car and sea robins on the bottom of Great Harbor, observed by an aqualung diver, Mr. Robert Weeks of the Woods Hole Oceanographic Institution, show no obvious change in behavior during transmission of signals effective in suppressing the staccato call.

Discussion

Conditions bringing forth the grunting of sea robins suggest that this sound is part of a general alarm reaction. It may be of value in nature as an adjunct to the spiny armor of the species in discouraging enemies, but no evidence is available on this point.

That the staccato calling reaches its climax near the peak of the sea robin breeding season is strongly suggestive of a relation of this calling to breeding activities, and the possibility cannot be overlooked that the calls serve as a species recognition device in waters where visibility is rather poor. Mr. Robert Weeks has informed me that visibility on the bottom of Great Harbor beneath the raft was a little over 6 feet on 10 July, 1955, and that sea robins could be seen clearly within that distance moving over the bottom of the harbor. The calling is heard at night, as well as in the daytime. In a few instances during the summer, production of the staccato call was heard to follow various sharp percussive sounds—the discharge of a high-energy spark into the water, the explosion of a detonating cap in the harbor, and the slamming of the live car lid on the raft.

Since the first staccato calls of 1955 were heard from fishes caged at the surface, while sea robins characteristically feed on the bottom, it was thought that warming of surface waters might have initiated calling from surface specimens earlier than their calling would ordinarily have commenced. However, temperatures taken with a bathythermograph during July and August of 1955 showed that there was a thorough mixing of water over the 72-foot depth under the raft, and no records obtained showed over a two-degree F. variation in temperature from the surface to the bottom.

While the significance of the calling behavior of the sea robin to its survival and normal behavior is as yet undetermined, the observations reported have demonstrated that sound is significant to the behavior of sea robins. The work has demonstrated that it is possible to control sound production by these marine fishes with man-made sounds. The findings stand as an exception to the general rule (Moulton and Backus, 1955) that production of man-made sounds causes only quickened swimming movements of fishes.

It should also be of interest to students of marine animal noises that it is possible to incite, without handling or trapping, the calling of marine fishes by transmission of appropriate signals, thus making it possible to move experiments to the natural environment from the confines of laboratory tanks, which under the best of conditions suppress and may otherwise modify calling behavior.

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Summary

1. A vibrant grunt and a staccato call of sea robins in the Woods Hole area are described. Sounds similar to these can be obtained by manipulation of the air bladder and by stimulation of the nerves to the drumming muscles.

2. It is suggested that the sea robin grunt is part of a general alarm reaction, and that the staccato call is related to the breeding behavior of the sea robin. It is suggested that the staccato call may serve as a species recognition device in waters where visibility is relatively poor.

3. A method of controlling production of the staccato call is described. Production of the call can be initiated by playing into the water imitations of the call and recordings of the call itself. The calling can be suppressed by playing of signals of 200 to 600 cps, and, less consistently, by playing of signals of 600 cps to 2 kc.

4. The results obtained furnish an exception to the general rule that sound production causes only quickened swimming movements of free fishes, and demonstrate the possibility of exercising some degree of control over the behavior of fishes in nature with man-made sounds.

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